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Comparison of Relative Emissions from Double Mechanical Pump Seals to other Types of Pump Shaft Seals

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Final Report

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INTRODUCTION

Data from the EPA refinery fugitive emissions study are compiled and analyzed in this report to compare emissions from double mechanical pumps to other types of pump shaft seals. Emission factors, leak rates, and percent leaking estimates are tabulated and the relative emissions from double mechanical pump seals and other types of seals are analyzed and interpreted.

A detailed description of the refinery data base, including screening and sampling procedures for pump seals, is available.[1]

[1]Radian Corporation, "Assessment of Atmospheric Emissions from Petroleum Refinery," Vol I-V, July 1980.

ANALYSIS OF PUMP SHAFT SEAL DATA

Pump seal data from nine petroleum refineries were extracted from the EPA Fugitive Emissions Data Base for comparison of emissions from double mechanical pump seals to other types of pump shaft seals. Separate comparisons were made for light liquid and heavy liquid service.

Nonmethane leak rates for single and double seals were compared using schematic plots.[2] Because the emission data has been shown to be lognormally distributed[3], a logarithmic transformation was performed before the schematic plots were made. As Figure 1-1 illustrates, seal type had practically no effect on leak rate for leaking seals in light liquid service. The medians and upper quartiles of the distributions of single and double seal leak rates were nearly equal, and the distributions completely overlapped. Although the upper quartile of the heavy liquid service double seal distribution is just above the lower quartile of the heavy liquid service single seal distribution, the two distributions also overlap, indicating that there is little difference between double seal and single seal leak rates for leaking pump seals in heavy liquid service. Emissions were measured on only nine heavy liquid double seals.

Centrifugal/mechanical pump, centrifugal/packed pump, and reciprocal/packed pump leak rates were also compared with schematic plots. The plots in Figure 1-2 illustrate that pump type had little effect on nonmethane leak rate for both light liquid and heavy liquid service. The distributions for all three pump types overlapped, and the upper quartiles were very close. The medians were also close, except for the light liquid service centrifugal/packed pump median, which was equal to the light liquid reciprocal/packed pump lower quartile.

The percentages of seals leaking and 95 percent confidence intervals about the percentage leaking were calculated to evaluate the tendency for pump shaft seals to leak. Calculation of confidence intervals is equivalent to performing a student's t-test on the groups of data. Nonoverlapping confidence intervals for two sets of data indicate that a t-test would show the averages of the two data sets to differ significantly. Similarly, overlapping confidence intervals indicate no significant difference between the averages of the data sets. This information is tabulated in Table 1-1. As the overlapping confidence intervals in Figure 1-3 illustrates, there was no significant difference in the percentage of seals leaking between the single and double seals for either light liquid or heavy liquid service.

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[2]Tukey, John W., Exploratory Data Analysis, Volume 1, Chapter 5. Reading, Massachusetts: Addison-Wesley Company, 1977.

[3]Wetherold, R. and Provost, L., Emission Factors and Frequency of Leak Occurrence for Fitting in Refinery Process Units, EPA-600/2-79-044, February 1979.

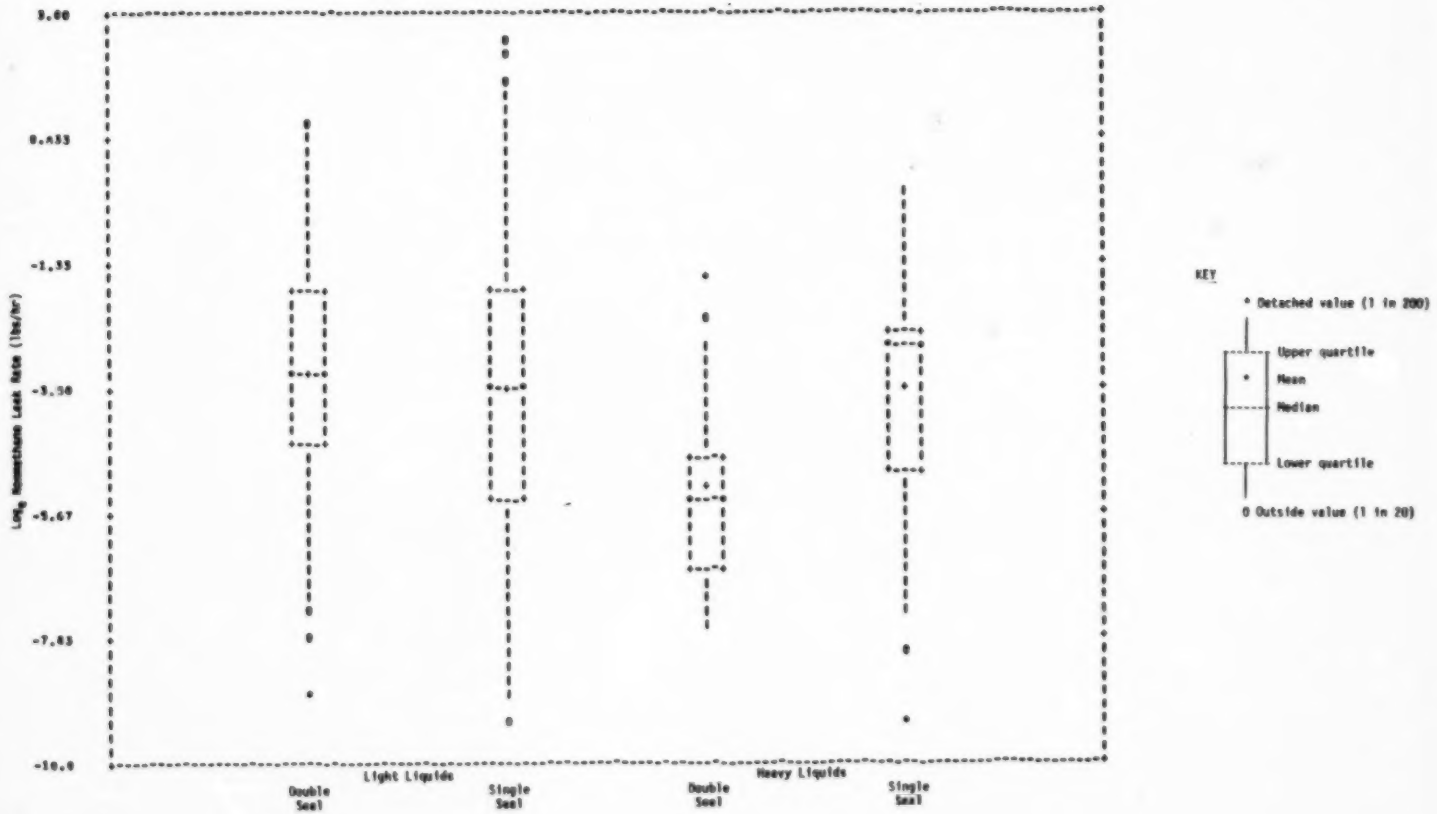


Figure 1-1. Schematic Plot of Pump Emissions by Seal Type

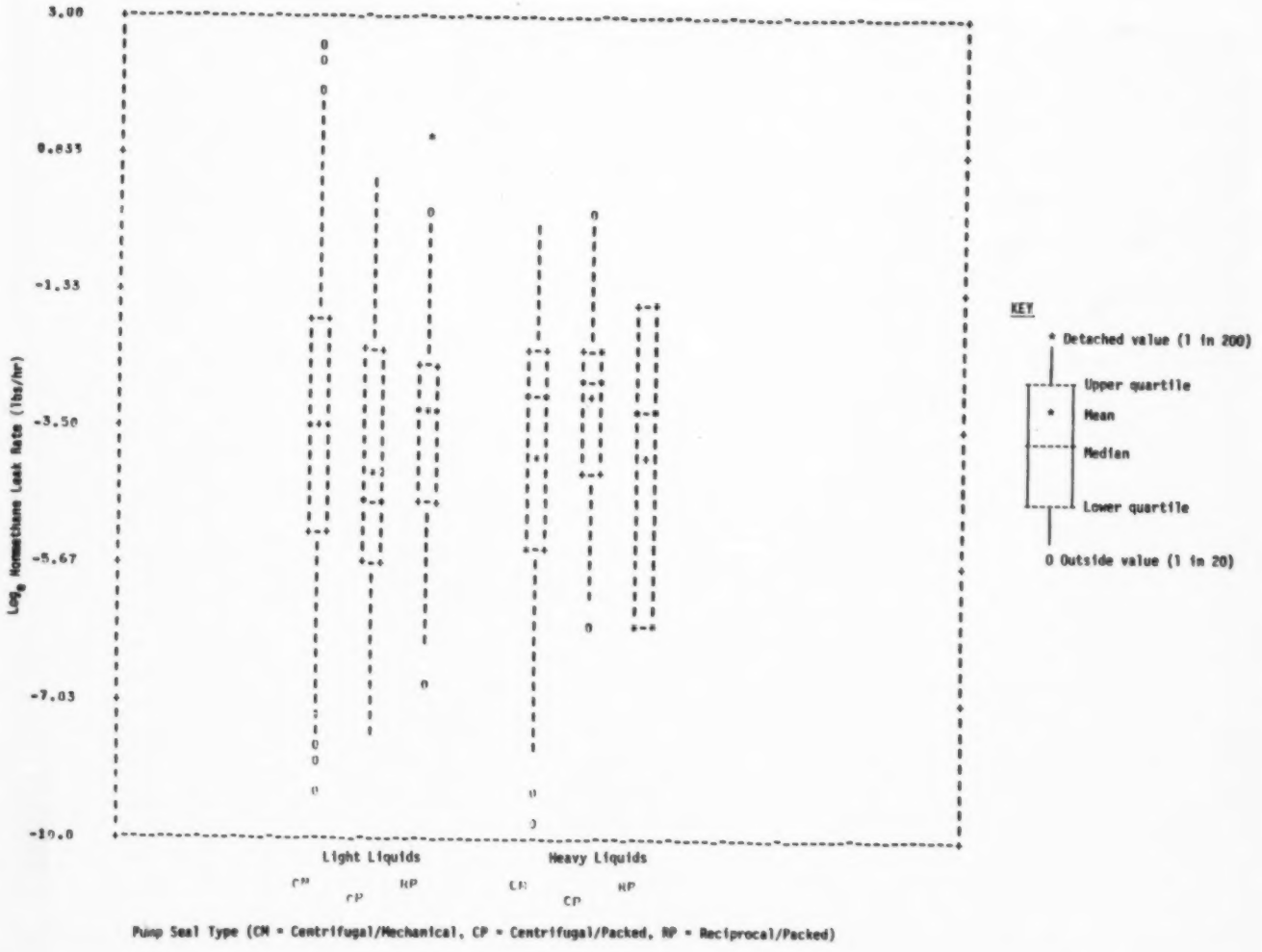
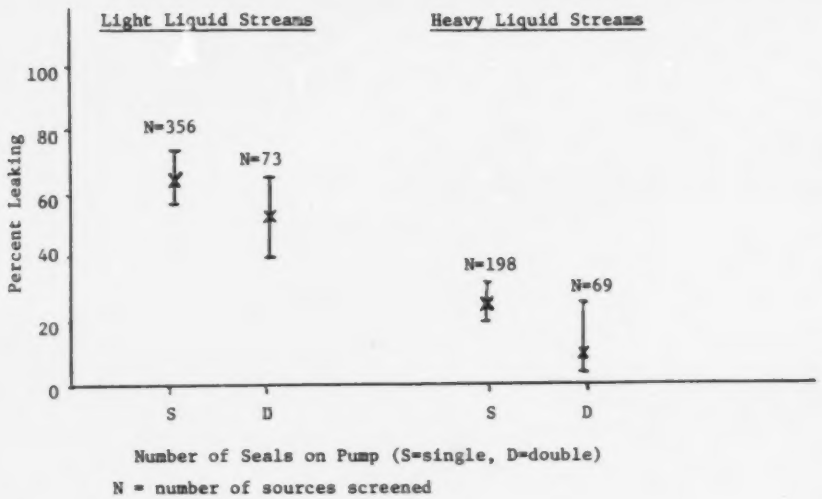


Figure 1-2. Schematic Plot of Pump Emissions by Pump Type

Table 1-1. Percent of Pump Seals Leaking and Emission Factors with 95% Confidence Limits

Pump/Seal	Number Screened	Number Leaking	% Leaking (95% Confidence Interval)	Estimated Emission Factor (lb/hr/seal)	95% Confidence Interval for Emission Factor (lb/hr/seal)
Light Liquid					
Double	73	38	52.0 (0.39, 0.66)	0.20	(.07, .55)
Single	356	229	64.3 (0.57, 0.72)	0.25	(0.16, 0.39)
Heavy Liquid					
Double	69	9	13.0 (.06, .27)	0.004	(.0003, .05)
Single	198	54	27.3 (.23, .32)	0.05	(.02, .11)
Light Liquid					
Pump = Centrifugal/ Mechanical	404	260	64.4 (.57, .72)	.25	(.16, .38)
= Centrifugal/ Packed	37	17	45.9 (.26, .67)	.18	(.01, .45)
= Reciprocal/ Packed	25	17	68.0 (.42, .88)	.25	(.04, 1.2)
Heavy Liquid					
Pump = Centrifugal/ Mechanical	217	48	22.1 (.19, .25)	.04	(.02, .10)
= Centrifugal/ Packed	50	15	22.1 (.16, .48)	.04	(.01, .16)
= Reciprocal/ Packed	23	3	13.0 (.02, .38)	.01	(10^{-6}, 16.0)
Light Liquid					
Seal = Double					
Pump = Centrifugal/ Mechanical	57	34	59.6 (.45, .74)	.25	(.08, .73)
= Centrifugal/ Packed	12	3	25.0 (.04, .63)	-	-
= Reciprocal/ Packed	3	1	33.3 (.03, .94)	-	-
Seal = Single					
Pump = Centrifugal/ Mechanical	313	203	64.8 (.59, .71)	.28	(.17, .41)
= Centrifugal/ Packed	24	13	54.2 (.28, .78)	.05	(.007, .77)
= Reciprocal/ Packed	18	13	72.2 (.41, .92)	-	-
Heavy Liquid					
Seal = Double					
Pump = Centrifugal/ Mechanical	49	7	14.3 (.03, .25)	.01	(10^{-4}, .13)
= Centrifugal/ Packed	11	2	18.2 (.08, .59)	-	-
= Reciprocal/ Packed	8	0	0.0 (0.00, .45)	-	-
Seal = Single					
Pump = Centrifugal/ Mechanical	147	38	25.8 (.18, .34)	.04	(.01, .11)
= Centrifugal/ Packed	37	13	35.1 (.17, .53)	.04	(.01, .14)
= Reciprocal/ Packed	13	3	23.1 (.03, .60)	-	-

- Sample size too small for valid estimate.



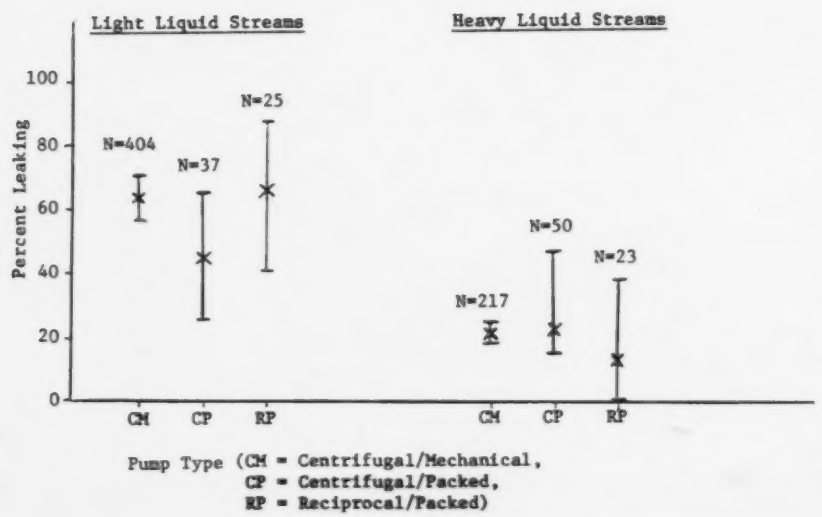


Figure 1-3. 95% Confidence Limits for Percentage of Pump Seals Leaking

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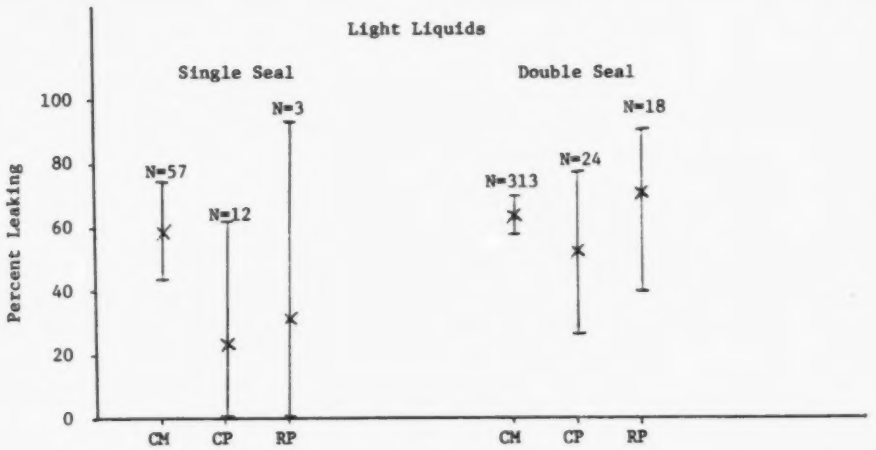
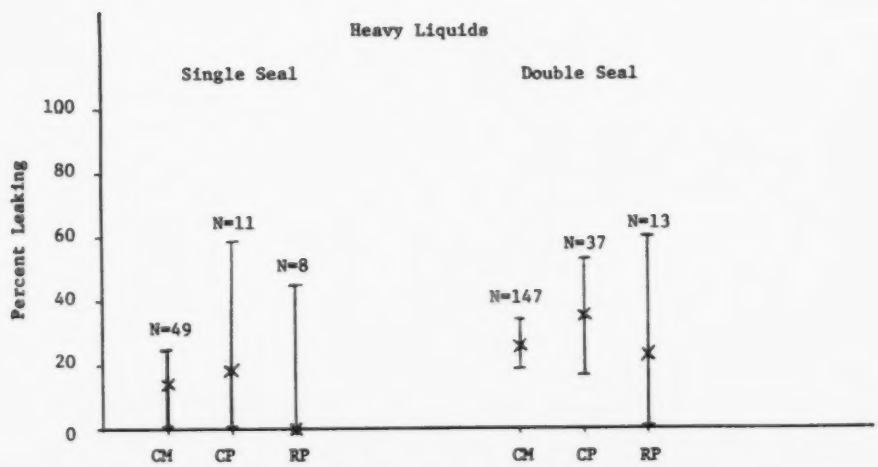


Pumps - effect of seal type and number of seals on percent of pumps leaking (CM = Centrifugal/Mechanical, CP = Centrifugal/Packed, RP = Reciprocal/Packed)



Pumps - effect of seal type and number of seals on percent of pumps leaking (CM = Centrifugal/Mechanical, CP = Centrifugal/Packed, RP = Reciprocal/Packed)

Figure 1-3. Continued

There was also no significant difference in the percentage of seals leaking among centrifugal/mechanical pumps, centrifugal/packed pumps, and reciprocal/packed pumps.

The percentage of seals leaking among centrifugal/mechanical pumps, centrifugal/packed pumps, and reciprocal/packed pumps were compared separately for single and double seal pumps and heavy and light liquid service in Table 1-1 and Figure 1-3. In all cases, the confidence intervals for the three types of pumps overlapped, indicating no significant difference among pump types for either single or double seals and light or heavy liquid service.

For a comparison of both the percentage of seals leaking and the amount of leakage per seal, emission factors and 95 percent confidence limits about the emission factors were also calculated and tabulated in Table 1-1. No emission factors were calculated for cases where the number of pump seals screened was less than 20 because confidence limits for such small sample sizes would have been extremely wide. For this reason, there was little information for comparison of the effect of pump seals on emission factors for any particular service and seal type. Where enough information for comparisons existed, all emission factor confidence intervals overlapped. This indicated that there was no significant difference in emission factors between single and double seals for either light or heavy liquid service, no significant difference in emission factors among centrifugal/mechanical, centrifugal/packed, and reciprocal/packed pumps for either light or heavy liquid service, and no significant difference between centrifugal/mechanical and centrifugal/packed pumps for single seal pumps and heavy liquid service.

CONCLUSIONS

Analysis of emissions from the refinery data base does not show significant differences between double mechanical pump seals and other types of pump shaft seals. Both the percentage of seals leaking and emission factors for double mechanical seals were similar to other types of seals in the data base. This is true for both heavy liquid and light liquid service.

Lack of significant differences may be due to the small amount of data available when subcategories of pump seals are analyzed. Also, the effect of other variables such as point of emission measurement, whether or not the pump was running, and the particulars of the service for each pump, may mask differences in performing of the various seal types.